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EVALUATION OF BIS(TRINITROETHYL)NITRAMINE AS A SUBSTITUTE FOR CYCLOTRIMETHYLENETRINITRAMINE (RDX) IN COMPOSITION A

15 April 1952

U. S. NAVAL ORDNANCE LABORATORY

WHITE OAK, MARYLAND

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Security Information

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EVALUATION OF BIS(TRINITROETHYL)NITRAMINE AS A SUBSTITUTE FOR CYCLOTRIMETHYLENETRINITRAMINE (RDX) IN COMPOSITION A

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ABSTRACT: Bis(trinitroethyl)nitramine, hereafter designated BTNEN, has been produced in sufficient quantity to permit fairly extensive evaluation as a military explosive. The preliminary evaluation of BTNEN as a substitute for RDX in Comp A-3 was done by the Explosives Properties Division.

BTNEN, in common with a number of other explosives including RDX, is too sensitive to mechanical shock to be acceptable as a military explosive. Therefore, a desensitizer and method of application which would yield an explosive composition analogous to Comp A-3 in impact sensitivity was first sought. BTNEN was combined with at least 60 different candidate desensitizers, and in some cases by several methods. Unfortunately BTNEN compositions which could be expected to compare favorably with Comp A-3 as an explosive, and which were satisfactorily desensitized were not obtained. Furthermore, the stabilities of most of the compositions containing BTNEN were unsatisfactory.

Evaluation of BTNEN Comp A-3 analogue was then undertaken without awaiting successful desensitization of the BTNEN. A Comp A-3 analogue containing 90% BTNEN and 10% Carnauba wax was selected for evaluation. The wax was chosen because it is brittle and can be ground to form an incoherent powder which mixes well with BTNEN. The 10 percent wax composition was chosen because that quantity utilizes most of the oxygen of the BTNEN to form carbon monoxide. A composition containing approximately 12.5% wax would have an oxygen balance of nearly zero on the carbon monoxide basis. Furthermore, the result of evaluation of the 90/10 composition would be more comparable with the results obtained from evaluation of the BTNEU/Aristowax 90/10 Comp A-3 analogue.

The booster sensitivity of the BTNEN/Carnauba 90/10 Comp A-3 analogue was found to be higher than that of Comp A-3 and the BTNEU/Aristowax Comp A-3 analogue. The relative brisance was found to

be higher than BTNEU/Aristowax Comp A-3 analogue and Comp A-3.

Explosive charges of the Comp A-3 analogue were made for fragmentation investigation, shaped charge evaluation, and detonation velocity measurements. These charges have been given to the Detonation Division who will report the results of their investigations. Approximately 35 pounds of the BTNEN/Carnauba wax 90/10 analogue has been made for the work of the two Divisions.

EXPLOSIVES RESEARCH DEPARTMENT
U.S. NAVAL ORDNANCE LABORATORY
WHITE OAK, MARYLAND

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The evaluation of BTNEN as a substitute for RDX in Comp A-3 reported here is a restricted phase of the broad program of development of new explosives sponsored by the Bureau of Ordnance. The work was authorized by Task Assignments NOL-Re2c-1-1-(EP), and NOL-Re2c-18-1. It is expected that subsequent reports from other Divisions will present the results of contribution to the evaluation of BTNEN as a substitute for RDX. Inasmuch as this report presents results of partial evaluation, it is intended for information only and not as basis for action.

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By direction

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evaluated in compositions containing 15% desensitizer. It was thought that compositions containing less explosive would compare unfavorably with accepted military explosives.

Desensitizers which could be conveniently melted in hot water were mixed by the slurry method. The BTNEN was suspended in hot water which had been heated to a temperature of 85°centigrade. The desensitizing material which had been melted was added to the BTNEN and water and stirred rapidly for about three minutes. The mixture was cooled by the addition of cold water and filtered. The filtered material was then washed and the coated BTNEN dried in an oven for 12 hours at 70°. The sensitivity was then determined by the method in use here, reference (a).

A number of the candidate desensitizers, which it was desired to evaluate, could not be effectively mixed by the hot water slurry method. These were dissolved in a limited amount of a solvent such as toluene, cyclohexane, carbon tetrachloride, or acetone. The BTNEN was then added to the solution in the proper ratio. After thorough mixing the solvent was evaporated by heating. The character of the resulting mixture depended on the relative solubilities of the BTNEN and desensitizer, particularly on which component crystallized first. If the BTNEN crystallizes first the desensitizer can be expected to form a coating on the explosive. This would also happen in case the BTNEN was insoluble. If the desensitizer came out of the solution first, the BTNEN crystals were deposited around the desensitizing material. In the event both materials came out of solution simultaneously a more intimate mixture would be formed. The available experimental data does not permit selection of a preferred order of crystallization.

Approximately sixty desensitizers were evaluated. Many of these were mixed with BTNEN by both the hot water slurry method and the solvent method described in the preceding paragraphs. In some cases application by the solvent method was repeated using a different solvent. For example, Arneel 18D a long chain fatty nitrile obtained from Armour and Company was dissolved in toluene and in carbon tetrachloride prior to application. Nearly 75 compositions were prepared and their sensitivities determined by the drop weight impact machine. The sensitivities of the BTNEN desensitizing materials, recorded in Table 1 were compared with the sensitivity of Comp A-3. When no sample could be found in this range of sensitivity, it was decided to determine whether substantially larger amounts of a wax, known to be an effective desensitizer, would desensitize BTNEN. Aristowax was chosen as a suitable material, and samples containing 10, 15, 25, 35, and 45% Aristowax were prepared by the solvent method using carbon tetrachloride as the solvent. The results included in Table 1 indicated that an excessively high percentage of wax was necessary to achieve satisfactory desensitization.

EVALUATION OF BIS(TRINITROETHYL)NITRAMINE AS A SUBSTITUTE FOR CYCLOTRIMETHYLENETRINITRAMINE (RDX) IN COMPOSITION A

Introduction

During the past several years the Bureau of Ordnance has been acting as sponsor of an extensive program of investigation and development of new explosives for military uses. Much of the work has been done in the laboratories of educational institutions, industrial and research organizations under contracts with the Bureau of Ordnance. From the many explosives thus developed a few have been selected for production on a small pilot plant scale in order to obtain material for more intensive evaluation. Bis(trinitroethyl)nitramine, (BTNEN), is one of those selected for this more intensive study. The structural formula of this explosive is:

$$\begin{array}{l} CH_2C(NO_2)_3 \\ | \\ N\text{-}NO_2 \\ | \\ CH_2C(NO_2)_3 \end{array}$$

The Hercules Powder Company was the contractor for the synthesis, development and final production of over 120 pounds of BTNEN for evaluation at the Naval Ordnance Laboratory. The first phase of this investigation was that of the BTNEN analogue of Comp A, that is, BTNEN was substituted for the RDX in Comp A. The results obtained by completion of this phase are reported herein.

Desensitization of BTNEN

The first objective in the Comp A-3 analogue phase of the BTNEN evaluation was the desensitization of the BTNEN. More specifically the objective was to find a desensitizer, a method of application, and to determine the minimum quantity required to produce a BTNEN Comp A-3 analogue of no greater impact sensitivity than Comp A-3. Acceptable chemical stability was also specified.

Inasmuch as the oxygen balance of BTNEN on the carbon monoxide basis is plus 30 whereas that of RDX is zero it was expected that a larger proportion of desensitizer could be tolerated in the analogue. In fact a composition of BTNEN/paraffin wax, ($C_{30}H_{62}$) containing 12.4% paraffin wax will have the same oxygen balance as RDX, while the composition containing 20.3% paraffin will have the same oxygen balance as Comp A-3. Therefore, the candidate desensitizers were first

Booster Sensitivity

The booster sensitivity test, reference (c), measures the 50% explosion efficiency height through a varied wax gap. The standard wax used is Acrawax B. One hundred grams of tetryl in 2 cylindrical pellets of 1-5/8" diameter are detonated by a number 8 detonator. The acceptor is a 5" charge, also 1-5/8" in diameter. The wax gap is varied between the tetryl donor and the acceptor in an up and down procedure to obtain the 50% height. Table 3 lists the booster sensitivity of BTNEN/Carnauba wax and some related explosives for comparative purposes. The number of test levels over which the explosive ranges is often higher in compositions where uniformity of the explosive may vary from charge to charge. This is more likely to be true of multi-component mixtures, aluminized explosives, and in the case of BTNEN/Carnauba wax, may be the result of not applying the wax uniformly to the particles of explosives. This would tend to cause a certain degree of inhomogeneity which might result in the somewhat erratic behavior in this test.

Relative Brisance of BTNEN/Carnauba Wax

A measure of the brisance of an explosive, reference (d) is determined by detonating an uncased 1-5/8" diameter charge 6 inches in height in contact with a steel plate 1-3/4" thick and 5" square. Comparative depths of dents are taken as the measure of brisance. The relative brisance of BTNEN/Carnauba wax 90/10 is compared with that of Comp A-3, TNT and BTNEU/Aristowax Comp A-3 analogue in Table 4.

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Table 1

Desensitization of BTNEN

Material	Solvent or Method	% Desensitizer Added	50% Height (cm)	Standard Deviation
Acrawax B	CCl_4	15	29	0.08
Acrawax B	"	15	24	0.08
African Bees-wax	"	15	15	0.12
Albacer Wax	"	15	14	0.14
Aristowax	"	10	21	0.03
Aristowax	"	15	18	0.15
Aristowax	"	25	23	0.07
Aristowax	"	35	29	0.06
Aristowax	"	45	47	0.48
Aristowax/SF 99 Dri Film* 22/14	Emulsion	36	22	0.11
Aristowax	Hot water slurry	15	22	0.03
Aristowax	Hot water slurry	10	32	0.07
Aristowax	Emulsion	18	13	0.09
Aristowax/SF 92 Dri Film* 15/2	Emulsion	17	18	0.09
Arneel 18-D	Toluene	10	17	0.12
Arneel 18-D	CCl_4	10	26	0.12
Azelaic Acid	"	15	18	0.08
B Square Special (N-53)	"	15	22	0.09
B Square Special (N-19)	"	15	23	0.07
B Square Special	Hot water slurry	15	16	0.23
Calcium Stearate	Dry mix	15	7	0.11
Calcium Stearate	CCl_4	15	13	0.15
Carnauba Wax	"	15	23	0.07
Carnauba Wax	Emulsion	15	12	0.06
Castor Wax	CCl_4	15	18	0.07
Chlorinated Rubber (Parlon)	"	15	11	0.09
Chloroparaffin Resin	"	15	9	0.05

*Trade name for General Electric silicone.

Table 1 (cont'd)

Desensitization of BTNEN

Material	Solvent or Method	% Desensitizer Added	50% Height (cm)	Standard Deviation
Stanolind Alox/ SF 99 Dri Film 15/5	Cold water slurry	20	25	0.03
Stanolind/Alox 98/2	CCl_4	15	17	0.14
Stanolind Wax	Hot water slurry	15	18	0.15
Stanolind Wax	CCl_4	15	17	0.06
Stearic Acid	Hot water slurry	15	16	0.07
Stearic Acid	CCl_4	15	23	0.11
Stearic Acid	"	20	25	0.02
Stearic Acid/ Polythene 15/5	Dry mix	20	13	0.09
Stearoxyacetic Acid	Hot water slurry	15	17	0.06
Stearoxyacetic Acid	CCl_4	15	19	0.18
Stearyl Hydrogen Diglycolate	Emulsion	10	19	0.08
Stearyl Hydrogen Diglycolate	Hot water slurry	15	29	0.13
Stearyl Hydrogen Diglycolate	CCl_4	15	21	0.06
Sunwax 1290 Brown	Emulsion	15	54	0.19
Sunwax 1290 Yellow	CCl_4	15	20	0.09
Sunwax 1290 Brown	"	15	24	0.19
Sunwax 1290 Brown	Hot water slurry	15	12	0.25
TM 700 Amber Wax	CCl_4	15	18	0.08
Urea Nitrate	"	15	9	0.05
Victory Amber Wax	Hot water slurry	15	23	0.12

Table 1 (cont'd)

Desensitization of BTNEN

Material	Solvent or Method	% Desensitizer Added	50% Height (cm)	Standard Deviation
Stanolind Alox/ SF 99 Dri Film 15/5	Cold water slurry	20	25	0.03
Stanolind/Alox 98/2	CCl_4	15	17	0.14
Stanolind Wax	Hot water slurry	15	18	0.15
Stanolind Wax	CCl_4	15	17	0.06
Stearic Acid	Hot water slurry	15	16	0.07
Stearic Acid	CCl_4	15	23	0.11
Stearic Acid	"	20	25	0.02
Stearic Acid/ Polythene 15/5	Dry mix	20	13	0.09
Stearoxyacetic Acid	Hot water slurry	15	17	0.06
Stearoxyacetic Acid	CCl_4	15	19	0.18
Stearyl Hydrogen Diglycolate	Emulsion	10	19	0.08
Stearyl Hydrogen Diglycolate	Hot water slurry	15	29	0.13
Stearyl Hydrogen Diglycolate	CCl_4	15	21	0.06
Sunwax 1290 Brown	Emulsion	15	54	0.19
Sunwax 1290 Yellow	CCl_4	15	20	0.09
Sunwax 1290 Brown	"	15	24	0.19
Sunwax 1290 Brown	Hot water slurry	15	12	0.25
TM 700 Amber Wax	CCl_4	15	18	0.08
Urea Nitrate	"	15	9	0.05
Victory Amber Wax	Hot water slurry	15	23	0.12

Table 4

Brisance of BTNEN/Carnauba Wax

Explosives	Density (gm/cc)	Relative Brisance
TNT	Cast 1.60	100
BTNEU/Aristowax 90/10	1.60	119
Comp A-3	1.60	121
BTNEN/Carnauba Wax	1.72	131

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(a) NavOrd Report 1589, Impact Sensitivity Determinations of Explosive Compounds Tested During the Period From 1 January 1950 to 1 November 1950, N.D. Mason, 1 November 1950.

(b) NavOrd Report 1757, Properties of Bis(Trinitroethyl)Nitramine, BTNEN, J.M. Rosen, 18 December 1950.

(c) NOLM 10336, The Sensitivity of High Explosives to Pure Shocks, E.H. Eyster, L.C. Smith and S.R. Walton, 14 July 1949.

(d) OSRD 5746, Physical Testing of Explosives Part III Miscellaneous Sensitivity and Performance Tests, L. C. Smith and E. H. Eyster, 27 December 1945